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Effect of Two Polysaccharide Adjuvants on Glyphosate Spray Droplet Size and Efficacy

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Laboratory and field studies were conducted to determine the effect of the drift control adjuvants HM 2005B and HM 9752 on the droplet spectra and efficacy of spray mixtures of a potassium salt formulation of glyphosate. Droplet spectra were examined using a laser spray droplet analyzer. The addition of each adjuvant decreased the percentage of the spray volume in small diam spray droplets (<141 μm) and either had no effect or increased glyphosate efficacy. These adjuvants could prove useful for providing management in potential drift situations.

Nomenclature: Glyphosate.

Key words: Flat fan nozzle, drift control, laser droplet size analyzer, *Abutilon theophrasti* Medik. ABUTH, *Echinochloa crus-galli* (L.) Beauv. ECHCG, *Ipomoea lacunosa* L. IPOLA.

Introduction

Glyphosate is a nonselective postemergence herbicide which is widely used on a broad spectrum of weed species in noncrop situations without residual effects. The recent development of transgenic, glyphosate-resistant agronomic crops has further increased the use of glyphosate as a post-emergence herbicide in cropping situations (Li et al. 2005).

This shift to transgenic glyphosate-resistant agronomic crops has intensified the need to control glyphosate spray drift to nearby nonresistant plants (Mueller and Womac 1997; Ramsdale and Messersmith 2001). Traditional methods for controlling spray drift include increasing droplet size by modification of the spray nozzles and by the use of drift control adjuvants (Bode et al. 1976). A study conducted by the Spray Drift Task Force (1997), a consortium of 38 agricultural companies, reported that the percentage of the spray volume in droplets less than 150 μm in diam was the most useful measure for evaluating the drift potential of an agriculture spray. Droplet size has been most commonly increased by reducing the spray pressure and/or increasing the nozzle orifice size.

Adjuvants used to control drift include viscosity-modifying polymers that combine with spray mixtures and increase spray droplet sizes, which reduces the movement of the spray mixture from the target plants. Among these drift control agents (DCA) are polysaccharides, with two of the most commonly used being guar and xanthan gums (McMullan 2000).

Akesson et al. (1994) reported that polysaccharides of naturally occurring gums, agars, and algin could serve as thickening or viscous adjuvants in water-based spray mixtures. Hazen (1996) found the polysaccharide guar gum to have the ability to increase the viscosity of water-based spray mixtures and effectively reduce the percentage of the spray volume in droplets below 150 μm. However, it has been cautioned on the glyphosate registration that DCAs with certain glyphosate formulations may result in reduced efficacy (Anonymous 2005).

Inorganic salts have been used as adjuvants to increase the phytotoxicity of many herbicides. Harris and Hyslop (1942) increased the activity of the sodium salt of 4,6-dinitro-*o*-cresol (DNOC) on many weed species by adding ammonium sulfate to the spray solution. McWhorter (1971) with johnsongrass [*Sorghum halepense* (L.) Pers.] and Wills (1971) with purple nutsedge (*Cyperus rotundus* L.) enhanced the phytotoxicity of MSMA and dalapon by the addition of ammonium sulfate and potassium phosphate to the spray solutions. Wills (1973) reported that ammonium sulfate and potassium phosphate each increased the phytotoxicity of glyphosate. Wills and McWhorter (1985) further reported that the monovalent cations NH_4^+ and K^+ in combination with anions including NO_3^-, Cl^-, and CO_3^{2-} increased the phytotoxicity of glyphosate.

Experiments were conducted to evaluate two polysaccharide adjuvants, one containing ammonium sulfate alone and one containing both ammonium sulfate and potassium phosphate, on the spray droplet size and efficacy of glyphosate as applied with a conventional flat fan nozzle.

Materials and Methods

General Procedures. Laboratory and field studies were conducted with the drift control adjuvants HM 2005B[1] and HM 9752[2] on the droplet size and efficacy of the herbicide glyphosate[3] as applied with conventional extended range 110015vs[4] (XR) spray nozzles.

Droplet Size. Droplet size spectra of the XR nozzle type was measured with a laser particle size analyzer.[5] Two methods were used to characterize the droplet size spectra. One was the volume median diam (VMD) which is the droplet size at which half the spray volume is composed of smaller droplets and half of larger droplets. The other was the percentage of the spray volume resulting in droplets less than 141 μm

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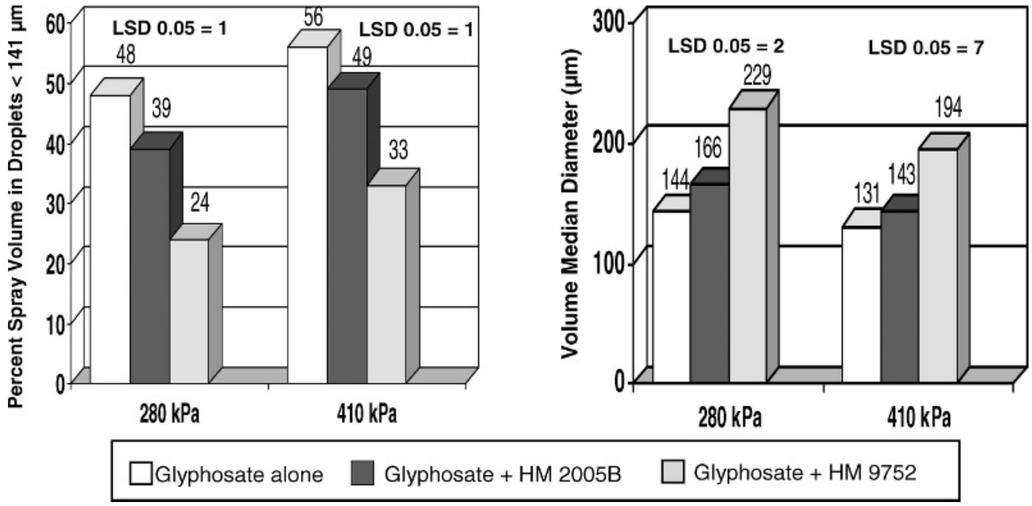

Figure 1. Effect of drift-control adjuvants HM 2005B and HM 9752 at 11 g/L and spraying pressures of 280 and 410 kPa on droplet size of glyphosate at 0.84 kg ae/ha, as indicated by percentage of spray volume in droplets smaller than 141 µm diam (left) and volume median diam of spray droplets (right).

(<141 µm) in diam, the same measure as used by the Spray Drift Task Force (1997). The nozzles selected produced a uniform spray pattern when tested on a spray pattern table.

The laser particle size analyzer was equipped with a pressure-regulated pumping system and a computer to perform data collection and analyses. The basic principles of this instrument are described by Mueller and Womac (1997).

The treatment mixtures analyzed were glyphosate at the commonly used rate of 0.84 kg ae/ha (Anonymous 2005) applied alone and with the drift control adjuvants HM 2005B and HM 9752 each at the rate of 11 g/L. Each treatment mixture was analyzed at the spray volume of 94 L/ha, nozzle height of 43 cm, and spray pressure of 280 kPa, the same as used in the field efficacy tests and again at the higher spray pressure of 410 kPa. Droplet size was measured parallel to the laser beam from the center out to 32 cm along the long axis of the spray pattern. The spray pattern was traversed parallel back and forth in four passes through the laser beam. The computer analyzed and presented the data as the average of the four passes.

Efficacy. Field research was conducted during 2003 and 2005 at Stoneville, MS, on Dundee silt loam (Typic Endoaqualfs) with 0.9% organic matter and pH 6.9. Pitted morningglory, barnyardgrass, and velvetleaf, were planted in rows consecutively spaced 1 m apart in two passes across all plots on April 23, 2003, and May 4, 2005. Individual treatment plots were each 4 by 12.5 m.

Glyphosate was applied at 0.42 kg ae/ha either alone or with the drift control adjuvant HM 9752 or HM 2005B at 11 g/L in water at the spray volume of 94 L/ha. Treatments were applied postemergence at 280 kPa spray pressure with the XR nozzle type using a tractor-mounted sprayer with nine nozzles spaced 48 cm apart along the boom and positioned at an average height of 43 cm above the average height of the velvetleaf canopy. Glyphosate was applied at one-half the commonly used rate in an effort to detect both increases and decreases in phytotoxicity among the various treatments. Application in 2003 and 2005 respectively was to 13- to 18-cm-tall and 25- to 30-cm-tall velvetleaf, 13- to 18-cm-tall and 20- to 25-cm-tall pitted morningglory, and 10- to 15-cm-tall and 20- to 30-cm-tall barnyardgrass.

Percent control of each weed species was visually evaluated to the nearest 5% level based on growth reduction and foliar chlorosis as compared to the nontreated control plots at 2 wk after treatment whereby 0 = no injury and 100% = complete kill of shoots.

The experimental design for both the droplet size and the efficacy study was a randomized complete block. There were three replications for the droplet size analyses of the VMD and of the percentage of spray droplets <141 µm and four replications for the field efficacy study. The combined ANOVA across years for the efficacy studies indicated a significant year by treatment interaction, therefore, the efficacy data for each weed species are presented for each year. The droplet size analyses for the percent spray volume in fine droplets <141 µm and for the percent weed control were transformed by arcsine square root for ANOVA. Treatment means were separated by Fisher's protected LSD test at $P \leq 0.05$.

Results and Discussion

Droplet Size. The addition of the drift control adjuvants HM 2005B and HM 9752 to the glyphosate spray mixtures using the XR spray nozzles each resulted in a reduction in the percentage of the spray volume in fine droplets <141 µm and in an increase in the VMD of the spray droplets in micrometers (Figure 1). At the spray pressure of 280 kPa, the addition of each HM 2005B and HM 9752 resulted in 19 and 50% less of the spray volume in fine droplets <141 µm and in 15 and 59% larger volume median diam of spray droplets in micrometers respectively than with spray mixtures of glyphosate alone.

Table 1. Effect of the adjuvants HM 2005B and HM 9752 on efficacy[a] of glyphosate on pitted morningglory, barnyardgrass, and velvetleaf at 2 wk after treatment in 2003 and 2005.

Treatment	Rate[c]	Pitted morningglory[b]		Barnyardgrass		Velvetleaf	
		2003	2005	2003	2005	2003	2005
	kg ae/ha	%					
Glyphosate	0.42	94 a	88 b	96 a	86 b	93 b	81 b
Glyphosate + HM 2005B[d]	0.42	96 a	90 ab	97 a	98 a	95 ab	91 a
Glyphosate + HM 9752[d]	0.42	95 a	93 a	98 a	96 a	97 a	89 a

[a] Plant injury rated on 0 to 100% scale: 0% = no plant response and 100% = complete kill of shoot.

[b] Means within a column followed by the same letter are not significantly different, according to Fisher's protected LSD at P = 0.05.

[c] Spray volume was 94 L/ha.

[d] HM 2005B and HM 9752 each applied at 11 g/L.

The droplet size spectrum was also determined at the higher spray pressure of 410 kPa, which was 1.5-fold greater than 280 kPa, to provide droplet size spectra in a range of spray pressures. At this increased spray pressure, the effects of each adjuvant used in this study were proportionately similar to the effects at 280 kPa, but with the overall percentage of the spray volumes in droplets <141 μm being increased and the VMD of the spray droplets in micrometers being decreased.

The Spray Drift Task Force (1997) has noted that determining the VMD of a spray mixture is useful for analyzing the entire droplet spectrum, but that the most useful measure for evaluating drift potential is the percentage of spray volume in droplets less than 150 μm. The cut-off point of 141 μm used in this study was the closest value detected by the particle-measuring instrument near to the 150-μm value.

The Spray Drift Task Force further states, "The cut-off point of 141 or 150 microns, has been established as a guide to indicate which droplet sizes are most prone to drift. However, it is important to recognize that drift doesn't start and stop at 141 microns. Drift potential continually increases as droplets get smaller than 141 microns, and continually decreases as droplets get bigger." Results of these studies by the Spray Drift Task Force indicate that the reduction in fine spray droplets below 141 μm and the increase in the VMD as found by the addition of the drift control adjuvants HM 2005B and HM 9752 to the glyphosate formulation as used in this study have the potential for reducing the drift of these spray mixtures.

Efficacy. The addition of the drift control adjuvants HM 2005B and HM 9752 either had no effect or increased the efficacy of glyphosate over all plant species in this study in each of the 2 yr (Table 1). In 2003, plant injury was 93 to 96% with glyphosate alone and was maintained at 95 to 98% with the addition of each HM 2005B and HM 9752. In 2005, percent plant injury increased from 81 to 88% with glyphosate alone to 90 to 98% and to 89 to 96% with the addition of HM 2005B and HM 9752, respectively.

The occasional increase in efficacy associated with these adjuvants may be attributed to reduced drift which might result in a greater amount of glyphosate being directed to the target area. Also, the increases in efficacy derived from these adjuvants may be attributed in part to the inclusion of ammonium sulfate in the formulation of HM 9752 and ammonium sulfate plus potassium phosphate in the formulation of HM 2005B. These inorganic salts were previously reported to increase the phytotoxicity of glyphosate spray mixtures (Wills and McWhorter 1985).

Sources of Materials

[1] HM 2005B, proprietary blend of polysaccharide polymers, modified guar gum, ammonium sulfate and potassium phosphate, Helena Chemical Company, 255 Schilling Blvd., Collierville, TN 38017.

[2] HM 9752, proprietary blend of polysaccharide polymers, modified guar gum and ammonium sulfate, Helena Chemical Company, 255 Schilling Blvd., Collierville, TN 38017.

[3] Roundup WeatherMax® formulation, Monsanto Company, 880 North Lindbergh Blvd., St. Louis, MO 63167.

[4] Extended Range TeeJet®, Spraying Systems Company, 220 West North Ave., Wheaton, IL 60189.

[5] Malvern/INSITEC Instruments, 2110 Omega Road, Suite D, San Ramon, CA 94583.

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